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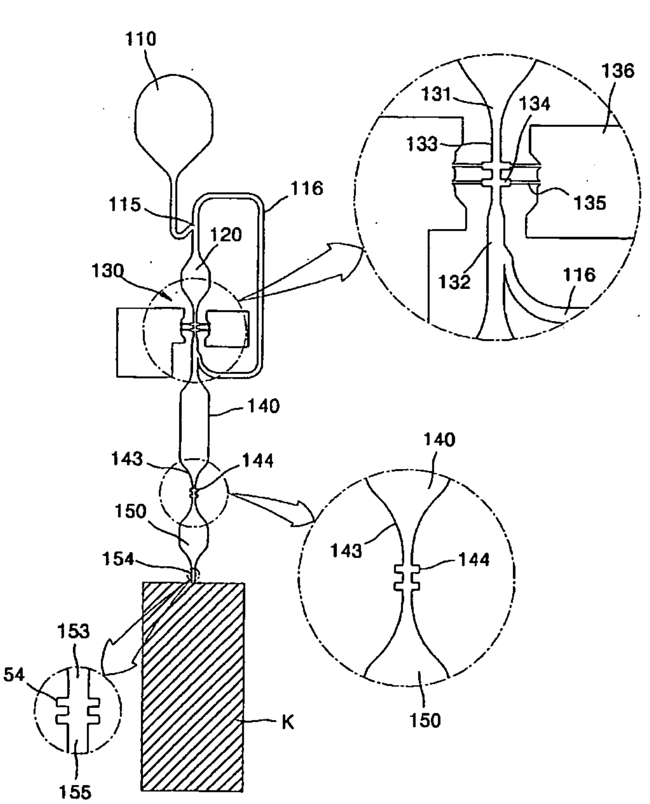
(54) Title: A CAPILLARY FLOW CONTROL MODULE AND LAB-ON-A-CHIP EQUIPPED WITH THE SAME



(57) Abstract: The present invention relates to a capillary flow control module and a lab-on-a-chip equipped with the same, and more particularly, a capillary flow control module and a lab-on-a-chip equipped with the same, which can diagnose and analyze a small amount of a sample by transferring and reacting the sample through the natural capillary flow by capillary phenomenon. The lab-on-a- chip equipped with the inventive capillary flow control module can connect a plurality of fluids by natural capillary flow without additional manipulation and energy through a specific design of channel configuration and diagnose and analyze two or more different samples by sequential transfer.

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A CAPILLARY FLOW CONTROL MODULE AND LAB-ON-A-CHIP EQUIPPED WITH THE SAME

TECHNICAL FIELD

The present invention relates to a capillary flow control module and a lab-on-a-chip equipped with the same, and more particularly, a capillary flow control module and a lab-on-a-chip equipped with the same, which can diagnose and analyze a small amount of a sample by transferring and reacting the sample through the natural capillary flow by capillary phenomenon.

BACKGROUND ART

The technology to transfer and control a small amount of microfluid is a core technology to drive a lab-on-a-chip and can be implemented by various driving methods. Examples of the methods for transferring and controlling microfluid include a pressure-driven method in which pressure is applied to a fluid injection part, an electrophoretic method or an electroosmotic method in which a voltage is applied between micro flow channels to transfer fluid, and a capillary flow method using the capillary phenomenon.

Among them, the capillary flow method which uses the capillary phenomenon naturally generated in micro flow channels has a merit in that it can spontaneously and promptly transfer a small amount of fluid around a fluid injection part through given channels, without an additional apparatus. Therefore, there have been actively conducted researches for

developing a device for transferring microfluid and a lab-on-a-chip using the capillary flow method.

DISCLOSURE OF THE INVENTION

Accordingly, the present invention has been made in order to meet such a current trend as described above, and it is an object of the present invention to provide a capillary flow control module and a lab-on-a-chip equipped with the same, which can transfer microfluids by the capillary phenomenon without any additional manipulation and energy.

It is another object of the present invention to provide a capillary flow control module which can combine a plurality of fluids by discharging air bubbles between fluids when the fluids meet each other in a capillary flow.

It is a further object of the present invention to provide a capillary flow control module and a lab-on-a-chip equipped with the same, which can sequentially transfer, react and analyze two or more samples.

It is a further object of the present invention to provide a lab-on-a-chip equipped with a capillary flow control module, which can remarkably improve the diagnosis system requiring many reaction steps and long reaction time, such as ELISA (Enzyme-Linked Immunosorbent Assay).

In order to achieve the above objects, the present invention provides a capillary flow control module comprising: a first channel 31 through which a first microfluid flows; a second channel 32 through which a second microfluid flows; a venturi channel 33 formed between the first channel 31 and the second channel 32; at least one flow delay part 34 formed in the venturi

channel 33 to delay the flow; and an air exhaust channel 35 connected to the flow delay part 34 to discharge air bubbles between the first microfluid and the second microfluid.

In the capillary flow control module according to the present invention, the venturi channel 33 has the same cross section shape as that of the first channel 31 and the second channel 32 and the air exhaust channel 35 has a smaller cross section area than that of the venturi channel 33. Also, an angle formed by the wall surface of the air exhaust channel and the wall surface extended from the air exhaust channel at the end of the air exhaust channel 35 is smaller than an angle formed by an inlet zone 11 and a delay boundary zone 13 at the flow delay part 34.

Also, the present invention provides a lab-on-a-chip equipped with the capillary flow control module comprising:

(a) a divergence channel 115 connected to a fluid injection part 110 containing a microfluid;

(b) an A reaction part 120 connected to the divergence channel 115 and containing A sample;

(c) a bypass channel 116 connected to the divergence channel 115,

(d) a capillary flow control module 130 comprising a first channel 131 connected to the A reaction part 120, a second channel 132 connected to the bypass channel 116, at least one first flow delay part 134 formed in a venturi channel 133 disposed between the first channel 131 and the second channel 132 to delay the flow, and an air exhaust channel 135 connected to the first flow delay part 134 to discharge air bubbles between the first microfluid and the second microfluid;

(e) a first charging part 140 connected to the second channel 132;

(f) a B reaction part 150 connected to the first charging part 140 and containing B sample; and

(g) a second flow delay part 144 formed in a venturi channel 143 between the first charging part 140 and the B reaction part 150.

The lab-on-a-chip according to the present invention may further comprise a third flow delay part 154 formed in a venturi channel 153 at the end of the B reaction part 150. Also, according to the present invention, a second charging part 160 and a third charging part 170 may be connected to the end of the B reaction part 150 via a venturi channel, in which the third charging part 170 is connected to an outlet part 190. Further, according to the present invention, a fourth flow delay part 174 formed in a venturi channel is provided between the third charging part 170 and the outlet part 190.

Also, the present invention provides a lab-on-a-chip equipped with the capillary flow control module comprising:

(a) a divergence channel 215 connected to a fluid injection part 210 containing a microfluid;

(b) an A reaction part 220 connected to the divergence channel 215 and containing an A sample;

(c) a first bypass channel 216 connected to the divergence channel 215;

(d) a first capillary flow control module 230 disposed between the A reaction part 220 and the first bypass channel 216;

(e) a first charging part 240 connected to the first capillary flow control module 230;

(f) a second capillary flow control module 330 connected to the first charging part 240;

(g) a second bypass channel 217 diverged from the first bypass channel 216 and connected to the second capillary flow control module 330;

(h) a B reaction part 250 connected to the second capillary flow control module 330 and containing a B sample;

(i) a third capillary flow control module 430 connected to the B reaction part 250;

(j) a third bypass channel 218 diverged from the second bypass channel 217 and connected to the third capillary flow control module 430;

(k) a second charging part 260 connected to the third capillary flow control module 430;

(l) a C reaction part 270 connected to the second charging part 260 and containing a C sample; and

(m) a fourth flow delay part 264 formed in a venturi channel 263 between the second charging part 260 and the C reaction part 270.

The present invention may further comprise a fifth flow delay part 274 formed in a venturi channel 273 at the end of the C reaction part 270.

Also, the present invention provides a lab-on-a-chip equipped with the capillary flow control module comprising:

(a) a divergence channel 215 connected to a fluid injection part 210 containing microfluid;

(b) an A reaction part 220 connected to the divergence channel 215 and containing an A sample;

(c) a first bypass channel 216 connected to the divergence channel 215;

(d) a first capillary flow control module 230 disposed between the A reaction part 220 and the first bypass channel 216;

(e) a first charging part 240 connected to the first capillary flow control module 230;

(f) a second capillary flow control module 330 connected to the first charging part 240;

(g) a second bypass channel 217 diverged from the first bypass channel 216 and connected to the second capillary flow control module 330;

(h) a B reaction part 250 connected to the second capillary flow control module 330 and containing a B sample;

(i) a third capillary flow control module 430 connected to the B reaction part 250;

(j) a third bypass channel 218 diverged from the second bypass channel 217 and connected to the third capillary flow control module 430;

(k) a second charging part 260 connected to the third capillary flow control module 430;

(l) a fourth capillary flow control module 530 connected to the second charging part 260;

(m) a C reaction part 270 connected to the fourth capillary flow control module 530 and containing a C sample;

(n) a sixth flow delay part 284 connected to the C reaction part 270 and an additional sample inlet part 280 to receive another sample; and

(o) a detection part 290 connected to the sixth flow delay part 284.

According to the present invention, the detection part 290 is sequentially connected to first, second, third and fourth outlet parts 300, 303, 306 and 309, a flow stopping part 310 and an air exhaust port 320 via a venturi channel, and a seventh flow delay part 301 and an eighth flow delay part 304 are provided in venturi channels between the first outlet part 300 and the second outlet part 303 and between the third outlet part 306 and the fourth outlet part 309, respectively.

According to the present invention the first capillary flow control module 230 comprises a first channel 231 connected to the A reaction part 220, a second channel 232 connected to the first bypass channel 216, a venturi channel 233 disposed between the first channel 231 and the second channel 232, at least one first flow delay part 234 formed in the venturi channel 233 to delay the flow, and an air exhaust channel 235 connected to the first flow delay part 234

to discharge air bubbles between the first microfluid and the second microfluid.

According to the present invention, the second capillary flow control module 330 comprises a first channel 331 connected to the first charging part 240, a second channel 332 connected to the second bypass channel 217, a venturi channel 333 disposed between the first channel 331 and the second channel 332, at least one second flow delay part 334 formed in the venturi channel 333 to delay the flow, and an air exhaust channel 335 connected to the second flow delay part 334 to discharge air bubbles between the first microfluid and the second microfluid.

According to the present invention, the third capillary flow control module 430 comprises a first channel 431 connected to the B reaction part 250, a second channel 432 connected to the third bypass channel 218, a venturi channel 433 disposed between the first channel 431 and the second channel 432, at least one third flow delay part 434 formed in the venturi channel 433 to delay the flow, and an air exhaust channel 435 connected to the third flow delay part 434 to discharge air bubbles between the first microfluid and the second microfluid.

According to the present invention, the fourth capillary flow control module 530 comprises a first channel 531 connected to the second charging part 260, a second channel 532 connected to the detection part 290, a venturi channel 533 formed between the first channel 531 and the second channel 532, at least one fourth flow delay part 534 formed in the venturi channel 533 to delay the flow, and an air exhaust channel 535 connected to the fourth flow delay part 534 to discharge air bubbles between the first microfluid and the second microfluid. Also, the fourth capillary flow control module 530 may further

comprise a flow stopping part 538 disposed between the second channel 532 and the fourth flow delay part 534 to stop the flow of the fluid.

According to the present invention, a substrate is previously added to the A reaction part 220, an enzyme-detection antibody complex is previously added to the B reaction part 250 and a capture antibody is previously fixed on the C reaction part 270. Also, silver nitrate and hydroquinone as a reducing agent are previously added to the A reaction part 220, gold-detection antibody complex is previously added to the B reaction part 250 and capture antibody is previously fixed onto the C reaction part 270.

The lab-on-a-chip according to the present invention comprises a signal detection part of the capillary flow control module applicable to the conventional well plate detecting apparatus and thus can detect signals using the convention well plate detecting apparatus.

The above and other features and embodiments of the present invention will be more fully apparent from the following detailed description and appended claims.

BRIEF DESCRIPTION OF DRAWINGS

The following description refers in more detail to the various features of the present invention. To facilitate an understanding of the invention, reference is made in the description to the accompanying drawings, in which:

FIG. 1 is a schematic view of an ordinary micro flow channel;

FIG. 2 is a schematic view of a flow delay model;

FIG. 3 is a photograph illustrating flow change in the flow delay model of FIG. 2;

FIG. 4 shows an air bubble trapped in a micro flow channel when two fluids meet in the micro flow channel;

FIG. 5 shows the construction of the capillary flow control module according to the present invention;

FIG. 6 shows a first embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention;

FIG. 7 shows a second embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention;

FIG. 8 shows a third embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention; and

FIG. 9 shows a fourth embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Now, the capillary flow control module according to the present invention and the lab-on-a-chip equipped with the same are described in detail, making reference to the attached drawings. Prior to description of the capillary flow control module and the lab-on-a-chip equipped with the same according to the present invention, capillary flow phenomenon is to be briefly described.

FIG. 1 shows a schematic view of an ordinary micro flow channel, FIG. 2 shows a schematic view of a flow delay model, FIG. 3 shows photographs illustrating flow change in the flow delay model of FIG. 2, and FIG. 4 shows an air bubble trapped in a micro flow channel when two fluids meet in the micro flow channel.

A capillary flow occurs when a gas-liquid interface is curved with a curvature due to discontinuous change of pressure generated on the gas-liquid

interface. The interface curvature is produced by a contact angle (θ) formed by the gas-liquid interface and a solid wall surface at a triple point, where the gas-liquid interface and the solid wall surface come into contact with each other. It is general that the contact angle is defined as an angle between the gas-liquid interface and the wall surface toward the liquid side, in which it is $0 < \theta < \pi/2$, when the wall surface is more affinitive to the liquid than it is to the gas and $\pi/2 < \theta < \pi$, when it is the opposite. If corner effect of a channel is disregarded, when the cross section of the channel through which fluid flows is a rectangle, as shown in FIG. 1, the pressure change except the flow effect can be expressed as follows.

$$\Delta P = P_0 - P_a = \Gamma(1/b + 1/c)\cos\theta$$

Such capillary flow can be delayed by a flow delay model 10, as shown in FIG. 2. That is, when a fluid is introduced to an inlet zone 11, the flow delay takes place in a delay boundary zone 12 which is a boundary zone between the inlet zone 11 and a flow delay zone 13 and this delay effect continues while the fluid passes through the delay boundary zone 12. Then, the capillary flow which has passed through the delay boundary zone 12 flows the flow delay zone 13 and reaches a recovery boundary zone 14 which is a boundary zone between the flow delay zone 13 and a flow recovery zone 15, upon which the interface curvature is increased whereby the fluid recovers its former flow rate. In the flow recovery zone 15, the capillary flow completely recovers its former flow rate and the flow continues.

FIG. 3 shows photographs of the actual condition in which the flow is delayed by the flow delay model of FIG. 2. Since the capillary flow was initiated in the inlet part 11, it has taken about 2 minutes and 7.63 seconds for the flow to reach to the next inlet part 11', while it took about only 0.5 second for the flow to pass through the second inlet part 11'. This is because the capillary flow is

delayed in the delay boundary zone 12, the flow delay zone 13 and the recovery boundary zone 14, as shown in FIG. 2.

Meanwhile, as shown in FIG. 4, when fluids, introduced from a first channel 21 and a second channel 22 which are formed in the opposite direction, respectively, flow capillarily and meet each other in a venturi channel 23 between the first channel and the second channel, an air bubble 24 may be trapped between the two fluids. Here, the flow of the two fluids is stopped by the air bubble 24 trapped in the venturi channel 23. In order for the flow to be resumed, an external force should be applied or the air bubble 24 should be removed.

FIG. 5 shows the construction of the capillary flow control module according to the present invention. As shown in the drawing, the capillary flow control module 30 according to the present invention is designed by employing the flow delay model 10 of FIG. 2 to solve the problem associated with the discharge of the air bubble, as shown in FIG. 4.

That is, the capillary flow control module 30 comprises a first channel 31 through which a first microfluid flows, a second channel 32 through which a second microfluid flows, a venturi channel 33 formed between the first channel 31 and the second channel 32, at least one flow delay part 34 formed in the venturi channel 33 to delay the flow, and an air exhaust channel 35 connected to the flow delay part 34 to discharge air bubbles between the first microfluid and the second microfluid. The air exhaust channel 35 is connected to an external air exhaust port 36.

Here, the flow delay part 34 has the same construction as the flow delay model 10, shown in FIG. 2. That is, the flow delay part 34 comprises an inlet zone

11, a delay boundary zone 12, a flow delay zone 13, a recovery boundary zone 14 and a flow recovery zone 15.

The capillary flows of the first microfluid and the second microfluid introduced through the first channel 31 and the second channel 32 are delayed by the flow delay part 34, upon which air bubbles existing between the first microfluid and the second microfluid are discharged through the air exhaust channel 35 and the air exhaust port 36, whereby the first microfluid is completely connected to the second microfluid.

Next, a first embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention is described. FIG. 6 shows the first embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention.

The first embodiment of the lab-on-a-chip comprises a divergence channel 115 connected to a fluid injection part 110 containing a microfluid, an A reaction part 120 connected to the divergence channel 115 and containing A sample, a bypass channel 116 connected to the divergence channel 115, a capillary flow control module 130 disposed between the A reaction part 120 and the bypass channel 116, a B reaction part 150 containing a B sample, and a first charging part 140 disposed between the B reaction part 150 and the capillary flow control module 130. Also, the B reaction part 150 is connected to a diagnosis/analysis part (K) for diagnosing and analyzing the fluid which has passed through the B reaction part 150.

Here, the capillary flow control module 130 comprises a first channel 131 connected to the A reaction part 120, a second channel 132 connected to the bypass channel 116, a venturi channel 133 disposed between the first channel 131 and the second channel 132, at least one first flow delay part 134 disposed

in the venturi channel 133 to delay the flow, and an air exhaust channel 135 connected to the first flow delay part 134 to discharge air bubbles between the first microfluid and the second microfluid. The air exhaust channel 135 is connected to an external air exhaust port 136.

Also, a venturi channel 143 is formed between the first charging part 140 and the B reaction part 150 and a second flow delay part 144 is formed in the venturi channel 143. Another venturi channel 153 is formed at the end of the B reaction part 150 and a third flow delay part 154 is formed in the venturi channel 153.

By the above-described structure, the fluid supplied through the fluid injection part 110 is divided into two directions in the divergence channel 115, in which one is transferred to the bypass channel 116 and the other is transferred to the A reaction part 120 to fill up the A reaction part 120.

The fluid transferred to the A reaction part 120 dissolves the A sample which has been previously put into the A reaction part 120 and is, then, transferred to the capillary flow control module 130. The flow of the fluid containing the A sample which is transferred to the capillary flow control module 130 is delayed in the first flow delay part 134.

Meanwhile, while the flow of the fluid which has passed through the A reaction part 120 is delayed in the first flow delay part 134, the fluid which has been transferred to the bypass channel 116 passes through the second channel 132 of the capillary flow control module 130 and fills up the first charging part 140, in which a part of the fluid is transferred to the first flow delay part 134.

When the fluid which has passed through the A reaction part 120 meets the fluid which has been transferred through the bypass channel 116 in the first flow delay part 134, air bubbles between the two fluids are discharged out of the air exhaust port 136 through the air exhaust channel 135 connected to the first flow delay part 134 whereby no air bubble is generated.

After completion of such fluid flow, the fluid which has been divided in the divergence channel 115 is united. Therefore, the upper side of the fluid which has passed through the bypass channel 116 contains the A sample. Next, the fluid which has passed through the first charging part 140 and the second flow delay part 144 is introduced to the B reaction part 150 to dissolve the B sample. Here, the flow of the fluid which has been introduced to the B reaction part 150 is delayed while the B sample is being dissolved by the third flow delay part 154 disposed at the end of the B reaction part 150. After a predetermined time passes, the fluid is transferred to the diagnosis/analysis part (K) or another capillary flow control module through the third flow delay part 154 and the discharge channel 155.

By the above-described driving mechanism, the fluid containing the B sample, the fluid without containing the sample and the fluid containing the A sample are sequentially introduced to the diagnosis/analysis part (K) at an interval of a predetermined time whereby it becomes possible to diagnose and analyze two different types of the A sample and the B sample.

Next, the second embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention is described. FIG. 7 shows the second embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention.

As shown in the drawing, the second embodiment differs from the first embodiment in that the end of the B reaction part 150 is connected to a second charging part 160 and a third charging part 170, instead of the diagnosis/analysis part (K) via a venturi channel and the third charging part 170 is connected to an outlet part 190. Also, a fourth flow delay part 174 formed in a venturi channel is disposed between the third charging part 170 and the outlet part 190. The operation of the lab-on-a-chip having the above-described structure is described as follows.

According to the second embodiment, a complex of an antigen and a fluorescent dye may be previously added to the A reaction part 120 and a capture antibody may be previously fixed on the B reaction part 150.

A buffer solution, which has been supplied to the fluid injection part 110, is transferred to the third flow delay part 154 by the flow processes described in FIG. 6. Then, while its flow is delayed by the third flow delay part 154, the buffer solution dissolves the antigen-fluorescent dye complex in the A reaction part 120 and activates the capture antibody of the B reaction part 150.

When the fluid which has been delayed in the third flow delay part 154 reaches the second charging part 160 and the third charging part 170 through the third flow delay part 154, the antigen-fluorescent dye complex contained in the A reaction part 120 is introduced to the B reaction part 150 for the antigen-antibody reaction with the capture antibody. Here, reaction time in the B reaction part 150 is controlled by the flow delay in the fourth flow delay part 174.

After a predetermined reaction time passes, the fluid delayed by the fourth flow delay part 174 is discharged through the outlet part 190 so that undesired

substances in the B reaction part 150 and non-specifically bonded antigen-antibody-fluorescent dye complex can be removed.

Next, the third embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention is described. FIG. 8 shows the third embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention.

As shown in the drawing, the third embodiment of the lab-on-a-chip according to the present invention relates to a lab-on-a-chip equipped with the capillary flow control module which can sequentially transfer three different samples and comprises a divergence channel 215 connected to a fluid injection part 210 containing a microfluid, an A reaction part 220 connected to the divergence channel 215 and containing an A sample, a first bypass channel 216 connected to the divergence channel 215, a first capillary flow control module 230 disposed between the A reaction part 220 and the first bypass channel 216, a first charging part 240 connected to the first capillary flow control module 230, a second capillary flow control module 330 connected to the first charging part 240, a second bypass channel 217 diverged from the first bypass channel 216 and connected to the second capillary flow control module 330, a B reaction part 250 connected to the second capillary flow control module 330 and containing a B sample, a third capillary flow control module 430 connected to the B reaction part 250, a third bypass channel 218 diverged from the second bypass channel 217 and connected to the third capillary flow control module 430, a second charging part 260 connected to the third capillary flow control module 430, and a C reaction part 270 connected to the second charging part 260 and containing a C sample. Also, a diagnosis/analysis part (K) is connected to the C reaction part 270 for diagnosing and analyzing components of the fluid which has passed through the C reaction part 270.

Here, the first capillary flow control module 230 comprises a first channel 231 connected to the A reaction part 220, a second channel 232 connected to the first bypass channel 216, a venturi channel 233 disposed between the first channel 231 and the second channel 232, at least one first flow delay part 234 formed in the venturi channel 233 to delay the flow, and an air exhaust channel 235 connected to the first flow delay part 234 to discharge air bubbles between the first microfluid and the second microfluid. An external air exhaust port 236 is connected to the air exhaust channel 235.

The second capillary flow control module 330 comprises a first channel 331 connected to the first charging part 240, a second channel 332 connected to the second bypass channel 217, a venturi channel 333 disposed between the first channel 331 and the second channel 332, at least one second flow delay part 334 formed in the venturi channel 333 to delay the flow, and an air exhaust channel 335 connected to the second flow delay part 334 to discharge air bubbles between the first microfluid and the second microfluid. The air exhaust channel 335 is connected to the air exhaust port 236 diverged from the first capillary flow control module 230.

The third capillary flow control module 330 comprises a first channel 431 connected to the B reaction part 250, a second channel 432 connected to the third bypass channel 218, a venturi channel 433 disposed between the first channel 431 and the second channel 432, at least one third flow delay part 434 formed in the venturi channel 433 to delay the flow, and an air exhaust channel 435 connected to the third flow delay part 434 to discharge air bubbles between the first microfluid and the second microfluid. The air exhaust channel 435 is connected to the air exhaust port 236 diverged from the first and second capillary flow control modules 230 and 330.

Also, a venturi channel 263 is formed between the second charging part 260 and the C reaction part 270 and a fourth flow delay part 264 is formed in the venturi channel 263. Another venturi channel 273 is formed at the end of the C reaction part 270 and a fifth flow delay part 274 is formed in the venturi channel 273. The operation of the above-described structure is described as follows.

A sample, B sample and C sample are previously added to the A reaction part 220, the B reaction part 250 and the C reaction part 270, respectively. The fluid supplied through the fluid injection part 210 is divided into two directions in the divergence channel 215, in which one is transferred to the first bypass channel 216 and the other is transferred to the A reaction part 220 to fill up the A reaction part 220.

While the flow of the fluid which has passed through the A reaction part 120 is delayed in the first flow delay part 234, the fluid which has been transferred to the first bypass channel 216 passes through the second channel 232 of the first capillary flow control module 230 and fills up the first charging part 240, upon which a part of the fluid is transferred to the first flow delay part 234.

When the fluid which has passed through the A reaction part 220 meets the fluid which has been transferred through the first bypass channel 216 in the first flow delay part 234, air bubbles between the two fluids are discharged out of the air exhaust port 236 through the air exhaust channel 235 connected to the first flow delay part 234 whereby no air bubble is trapped therebetween. With completion of the flow, the fluids disverged in the divergence channel 215 are united.

Also, the fluid which has diverged from the first bypass channel 216 and passed through the second bypass channel 217 fills up the B reaction part 250

and the second charging part 260 and air is discharged from the second flow delay part 334 and the third flow delay part 434 while the fluid which has reached the third flow delay part 264 is delayed, and then the fluids are united, based on the above-described flow mechanism. Thus, the fluids are connected from the A reaction part 220 to the fourth flow delay part 264.

If the fluid delay effect by the fourth flow delay part 264 is vanished, the fluid is supplied to the C reaction part 270 to dissolve the C sample while it is delayed by the fifth flow delay part 274.

After a predetermined time passes, when the delay effect of the fifth flow delay part 274 is vanished, the whole fluid is supplied to the diagnosis/analysis part (K) or another capillary flow control module through the discharge channel 275. By the above-described structure, the C sample, the B sample and the A sample may be sequentially supplied.

Next, the fourth embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention is described. FIG. 9 shows the fourth embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention, which is designed for sequential supply and reaction of three different samples, particularly according to the Enzyme-linked immunosorbent assay (ELISA). Here, the same reference numbers as in the third embodiment represent constructions with the same functions.

The fourth embodiment of the lab-on-a-chip equipped with the capillary flow control module according to the present invention comprises a divergence channel 215 connected to a fluid injection part 210 containing microfluid, an A reaction part 220 connected to the divergence channel 215 and containing an A sample, a first bypass channel 216 connected to the divergence channel 215,

a first capillary flow control module 230 disposed between the A reaction part 220 and the first bypass channel 216, a first charging part 240 connected to the first capillary flow control module 230, a second capillary flow control module 330 connected to the first charging part 240, a second bypass channel 217 diverged from the first bypass channel 216 and connected to the second capillary flow control module 330, a B reaction part 250 connected to the second capillary flow control module 330 and containing a B sample, a third capillary flow control module 430 connected to the B reaction part 250, a third bypass channel 218 diverged from the second bypass channel 217 and connected to the third capillary flow control module 430, and a second charging part 260 connected to the third capillary flow control module 430.

The second charging part 260 is connected to a fourth capillary flow control module 530 which is connected to a C reaction part 270 containing the C sample.

The C reaction part 270 is connected to a sixth flow delay part 284 which is connected to an additional sample inlet part 280 to receive another sample. The sixth flow delay part 284 is sequentially connected to a detection part 290, first, second, third and fourth outlet parts 300, 303, 306 and 309, a flow stopping part 310 and an air exhaust port 320 via a venturi channel. The venturi channels between the first outlet part 300 and the second outlet part 303 and between the third outlet part 306 and the fourth outlet part 309 are provided with a seventh flow delay part 301 and an eighth flow delay part 304, respectively.

Here, the first capillary flow control module 230 comprises a first channel 231 connected to the A reaction part 220, a second channel 232 connected to the first bypass channel 216, a venturi channel 233 formed between the first channel 231 and the second channel 232, at least one first flow delay part 234

formed in the venturi channel 233 to delay the flow, and an air exhaust channel 235 connected to the first flow delay part 234 to discharge air bubbles between the first microfluid and the second microfluid. The air exhaust channel 235 is connected to an external air exhaust port 236.

The second capillary flow control module 330 comprises a first channel 331 connected to the first charging part 240, a second channel 332 connected to the second bypass channel 217, a venturi channel 333 formed between the first channel 331 and the second channel 332, at least one second flow delay part 334 formed in the venturi channel 333 to delay the flow, and an air exhaust channel 335 connected to the second flow delay part 334 to discharge air bubbles between the first microfluid and the second microfluid. The air exhaust channel 335 is connected to the air exhaust port 236 diverged from the first capillary flow control module 230.

The third capillary flow control module 330 comprises a first channel 431 connected to the B reaction part 250, a second channel 432 connected to the third bypass channel 218, a venturi channel 433 formed between the first channel 431 and the second channel 432, at least one third flow delay part 434 formed in the venturi channel 433 to delay the flow, and an air exhaust channel 435 connected to the third flow delay part 434 to discharge air bubbles between the first microfluid and the second microfluid. The air exhaust channel 435 is connected to the air exhaust port 236 diverged from the first and second capillary flow control modules 230 and 330.

The fourth capillary flow control module 530 comprises a first channel 531 connected to the second charging part 260, a second channel 532 connected to the C reaction part 270, a venturi channel 533 formed between the first channel 531 and the second channel 532, at least one fourth flow delay part 534 formed in the venturi channel 533 to delay the flow, and an air exhaust

channel 535 connected to the fourth flow delay part 534 to discharge air bubbles between the first microfluid and the second microfluid. A flow stopping part 538 to stop the flow of the fluid from the C reaction part 270 is formed between the second channel 532 and the fourth flow delay part 534. The operation of the above-described structure is described as follows.

A substrate is previously added to the A reaction part 220, an enzyme-detection antibody complex is previously added to the B reaction part 250, and a capture antibody is previously fixed on the C reaction part 270.

The sample which has been introduced from the sample inlet part 280 is supplied to the C reaction part 270 via a sample inlet channel 281. The sample charged in the C reaction part 270 is stopped until a buffer solution supplied from the fluid injection part 210 passes through the fourth flow delay part 534 and reaches the flow stopping part 538, upon which the antigen contained in the sample binds with the capture antibody in the C reaction part 810.

After completion of the sample supply, the fluid supplied through the fluid injection part 210 is divided into two directions in the divergence channel 215, in which one is transferred to the first bypass channel 216 and the other is transferred to the A reaction part 220 to fill up the A reaction part 220.

The buffer solution transferred to the first bypass channel 216 is supplied to the first charging part 240, the B reaction part 250 and the second charging part 260 via the second bypass channel 217 and the third bypass channel 218.

Here, the buffer solution supplied to the first and second charging parts 240 and 260, and the B reaction part 250 is delayed and separated by the first flow delay part 234, the second flow delay part 334, the third flow delay part 434

and the fourth flow delay part 534, and dissolves the substrate of the A reaction part 220 and the enzyme-detection antibody complex of the B reaction part 250.

After the fluids delayed by the first, second and third flow delay parts 234, 334 and 434 are united and the delay effect of the fourth flow delay part 534 is vanished, the buffer solutions supplied to the reaction part and the charging part are connected to the sample stopped by the first flow stopping part 538. By this procedure, when the buffer solution and the sample from the two inlet parts are connected to each other and the effect of the sixth flow delay part 284 is vanished, the fluid fills up the detection part 290 and the first outlet part 300 and is delayed by the seventh flow delay part 301.

Here, the substrate and the enzyme-detection antibody complex which are present in the A reaction part 220 and the B reaction part 250 are transferred to the B reaction part 250 and the C reaction part 270, respectively. In the C reaction part 270, the enzyme-detection antibody complex and the antigen-capture antibody complex react by antigen-antibody reaction to form enzyme-detection antibody-antigen-capture antibody complex.

After the delay effect of the seventh flow delay part 301 disappears, the fluid fills up the second outlet part 303 and the third outlet part 306 and is delayed again by the eighth flow delay part 304. Here, the substrate in the B reaction part 250 is transferred to the C reaction part 270, in which it chemically reacts by the action of the enzyme existing therein.

Then, the fluid which has been delayed by the eighth flow delay part 304 is supplied to the third outlet part 309 and is stopped by the second flow stopping part 310. Meanwhile, the substrate which has chemically reacted in the C reaction part 270 is transferred to the detection part 290, in which it is

separated from the enzyme, whereby there is no more chemical reaction by the enzyme.

Here, it is possible to detect antigen in the sample supplied to the sample inlet part 280 by examining the signal of the substrate transferred to the detection part 290. Also, by locating the detection part 290 in the same manner as well locations of a well plate, it is possible to produce the capillary flow control module according to the present invention suitable to the conventional well plate detecting apparatuses.

In another embodiment employing the lab-on-a-chip of the fourth embodiment, silver nitrate and hydroquinone as a reducing agent are previously supplied to the A reaction part 220, gold-detection antibody complex is previously supplied to the B reaction part 250 and capture antibody is previously fixed onto the C reaction part 270.

By the same flow procedures as the described-above embodiments, the antigen of the sample is bonded with the capture antibody in the C reaction part 270 and sequentially, the gold-detection antibody complex in the B reaction part 250 is bonded with the antigen-capture antibody complex in the C reaction part 270 by the antigen-antibody reaction to form gold-detection antibody-antigen-capture antibody complex.

By the sequential transfer of the fluid, the silver nitrate and the hydroquinone solution of the A reaction part 220 reach the C reaction part 270, upon which silver ion in the silver nitrate solution is reduced to silver atom by catalytic reaction of gold present in the C reaction part 270. As a result of this reduction, a silver film is formed in the C reaction part 270. By measuring absorbance of the silver film, the antigen in the sample may be detected.

The micro flow channel used in the present invention may be formed by covering a plate with a depressed pattern with a flat plate or a plate with a depressed or raised pattern. The plate may be formed of polymers, metals, silicon, glass, PCB (Printed Circuit Board) and the like, preferably materials with polymers. Examples of the plate include plastics such as PMMA (polymethylmethacrylate), PC (polycarbonate), COC (cycloolefin copolymer), PDMS (polydimethylsiloxane), PA (polyamide), PE (polyethylene), PP (polypropylene), PPE (polyphenylene ether), PS (polystyrene), POM (polyoxymethylene), PEEK (polyetherketone), PTFE (polytetrafluoroethylene), PVC (polyvinylchloride), PVDF (polyvinylidene fluoride), PBT (polybutyleneterephthalate), and FEP (fluorinated ethylenepropylene). The above-listed materials may be largely shaped by replication methods such as injection molding, hot embossing or casting. Particularly, these materials are suitable for production of the micro flow channel according to the present invention due to their inactivity, processability, cheapness and disposability.

The method for producing the micro flow channel according to the present invention includes preparing a mold with a raised pattern corresponding to the shape of the micro flow channel, making a plate with a depressed pattern over the mold, adjusting hydrophilicity of the surfaces of each plate and the second plate, and binding the first plate to the second plate.

In the above embodiments, it is described that the capillary flow control module has a cross-section of a square but the present invention is not limited thereto. Thus, it is obvious that the capillary flow control module may have various shapes such as circle and trapezoid.

Although the present invention has been described in detail with reference to the specific features, it will be apparent to those skilled in the art that this description is only for a preferred embodiment and does not limit the scope of

the present invention. Thus, the substantial scope of the present invention will be defined by the appended claims and equivalents thereof.

INDUSTRIAL APPLICABILITY

As described above, by the capillary flow control module and the lab-on-a-chip equipped with the same according to the present invention, it is possible to connect a plurality of fluids by a specific design of channel configuration based on natural flow due to capillary force without additional manipulation and energy. Also, it is possible to sequentially transfer and diagnose/analyze two or more samples. Further, the capillary flow control module and the lab-on-a-chip equipped with the same according to the present invention can be easily manufactured and used in a simple manner.

THE CLAIMS

What is claimed is:

1. A capillary flow control module comprising: a first channel 31 through which a first microfluid flows; a second channel 32 through which a second microfluid flows; a venturi channel 33 formed between the first channel 31 and the second channel 32; at least one flow delay part 34 formed in the venturi channel 33 to delay the flow; and an air exhaust channel 35 connected to the flow delay part 34 to discharge air bubbles between the first microfluid and the second microfluid.

2. The capillary flow control module according to claim 1, wherein the venturi channel 33 has the same shape of cross section as the first channel 31 and the second channel 32.

3. The capillary flow control module according to claim 1, wherein the air exhaust channel 35 has a smaller cross section area than that of the venturi channel 33.

4. The capillary flow control module according to claim 1, wherein an angle formed by the wall surface of the air exhaust channel and the wall surface extended from the air exhaust channel at the end of the air exhaust channel 35 is smaller than an angle formed by an inlet zone 11 and a delay boundary zone 13 at the flow delay part 34.

5. A lab-on-a-chip equipped with the capillary flow control module comprising:

(a) a divergence channel 115 connected to a fluid injection part 110 containing a microfluid;

(b) an A reaction part 120 connected to the divergence channel 115 and containing A sample;

(c) a bypass channel 116 connected to the divergence channel 115,

(d) a capillary flow control module 130 comprising a first channel 131 connected to the A reaction part 120, a second channel 132 connected to the bypass channel 116, at least one first flow delay part 134 formed in a venturi channel 133 disposed between the first channel 131 and the second channel 132 to delay the flow, and an air exhaust channel 135 connected to the first flow delay part 134 to discharge air bubbles between the first microfluid and the second microfluid;

(e) a first charging part 140 connected to the second channel 132;

(f) a B reaction part 150 connected to the first charging part 140 and containing B sample; and

(g) a second flow delay part 144 formed in a venturi channel 143 between the first charging part 140 and the B reaction part 150.

6. The lab-on-a-chip according to claim 5, which further comprises a third flow delay part 154 formed in a venturi channel 153 at the end of the B reaction part 150.

7. The lab-on-a-chip according to claim 5, wherein a second charging part 160 and a third charging part 170 are connected to the end of the B reaction part 150 via a venturi channel, in which the third charging part 170 is connected to an outlet part 190.

8. The lab-on-a-chip according to claim 7, wherein a fourth flow delay part 174 formed in a venturi channel is provided between the third charging part 170 and the outlet part 190.

9. A lab-on-a-chip equipped with the capillary flow control module comprising:

(a) a divergence channel 215 connected to a fluid injection part 210 containing a microfluid;

(b) an A reaction part 220 connected to the divergence channel 215 and containing an A sample;

(c) a first bypass channel 216 connected to the divergence channel 215;

(d) a first capillary flow control module 230 disposed between the A reaction part 220 and the first bypass channel 216;

(e) a first charging part 240 connected to the first capillary flow control module 230;

(f) a second capillary flow control module 330 connected to the first charging part 240;

(g) a second bypass channel 217 diverged from the first bypass channel 216 and connected to the second capillary flow control module 330;

(h) a B reaction part 250 connected to the second capillary flow control module 330 and containing a B sample;

(i) a third capillary flow control module 430 connected to the B reaction part 250;

(j) a third bypass channel 218 diverged from the second bypass channel 217 and connected to the third capillary flow control module 430;

(k) a second charging part 260 connected to the third capillary flow control module 430;

(l) a C reaction part 270 connected to the second charging part 260 and containing a C sample; and

(m) a fourth flow delay part 264 formed in a venturi channel 263 between the second charging part 260 and the C reaction part 270.

10. The lab-on-a-chip according to claim 9, wherein the first capillary flow control module 230 comprises a first channel 231 connected to the A reaction

part 220, a second channel 232 connected to the first bypass channel 216, a venturi channel 233 disposed between the first channel 231 and the second channel 232, at least one first flow delay part 234 formed in the venturi channel 233 to delay the flow, and an air exhaust channel 235 connected to the first flow delay part 234 to discharge air bubbles between the first microfluid and the second microfluid.

11. The lab-on-a-chip according to claim 9, wherein the second capillary flow control module 330 comprises a first channel 331 connected to the first charging part 240, a second channel 332 connected to the second bypass channel 217, a venturi channel 333 disposed between the first channel 331 and the second channel 332, at least one second flow delay part 334 formed in the venturi channel 333 to delay the flow, and an air exhaust channel 335 connected to the second flow delay part 334 to discharge air bubbles between the first microfluid and the second microfluid.

12. The lab-on-a-chip according to claim 9, wherein the third capillary flow control module 430 comprises a first channel 431 connected to the B reaction part 250, a second channel 432 connected to the third bypass channel 218, a venturi channel 433 disposed between the first channel 431 and the second channel 432, at least one third flow delay part 434 formed in the venturi channel 433 to delay the flow, and an air exhaust channel 435 connected to the third flow delay part 434 to discharge air bubbles between the first microfluid and the second microfluid.

13. The lab-on-a-chip according to claim 9, which further comprises a fifth flow delay part 274 formed in a venturi channel 273 at the end of the C reaction part 270.

14. A lab-on-a-chip equipped with the capillary flow control module comprising:

(a) a divergence channel 215 connected to a fluid injection part 210 containing microfluid;

(b) an A reaction part 220 connected to the divergence channel 215 and containing an A sample;

(c) a first bypass channel 216 connected to the divergence channel 215;

(d) a first capillary flow control module 230 disposed between the A reaction part 220 and the first bypass channel 216;

(e) a first charging part 240 connected to the first capillary flow control module 230;

(f) a second capillary flow control module 330 connected to the first charging part 240;

(g) a second bypass channel 217 diverged from the first bypass channel 216 and connected to the second capillary flow control module 330;

(h) a B reaction part 250 connected to the second capillary flow control module 330 and containing a B sample;

(i) a third capillary flow control module 430 connected to the B reaction part 250;

(j) a third bypass channel 218 diverged from the second bypass channel 217 and connected to the third capillary flow control module 430;

(k) a second charging part 260 connected to the third capillary flow control module 430;

(l) a fourth capillary flow control module 530 connected to the second charging part 260;

(m) a C reaction part 270 connected to the fourth capillary flow control module 530 and containing a C sample;

(n) a sixth flow delay part 284 connected to the C reaction part 270 and an additional sample inlet part 280 to receive another sample; and

(o) a detection part 290 connected to the sixth flow delay part 284.

15. The lab-on-a-chip according to claim 14, wherein the detection part 290 is sequentially connected to first, second, third and fourth outlet parts 300, 303, 306 and 309, a flow stopping part 310 and an air exhaust port 320 via a venturi channel, and a seventh flow delay part 301 and an eighth flow delay part 304 are provided in venturi channels between the first outlet part 300 and the second outlet part 303 and between the third outlet part 306 and the fourth outlet part 309, respectively.

16. The lab-on-a-chip according to claim 14, wherein the first capillary flow control module 230 comprises a first channel 231 connected to the A reaction part 220, a second channel 232 connected to the first bypass channel 216, a venturi channel 233 disposed between the first channel 231 and the second channel 232, at least one first flow delay part 234 formed in the venturi channel 233 to delay the flow, and an air exhaust channel 235 connected to the first flow delay part 234 to discharge air bubbles between the first microfluid and the second microfluid.

17. The lab-on-a-chip according to claim 14, wherein the second capillary flow control module 330 comprises a first channel 331 connected to the first charging part 240, a second channel 332 connected to the second bypass channel 217, a venturi channel 333 disposed between the first channel 331 and the second channel 332, at least one second flow delay part 334 formed in the venturi channel 333 to delay the flow, and an air exhaust channel 335 connected to the second flow delay part 334 to discharge air bubbles between the first microfluid and the second microfluid.

18. The lab-on-a-chip according to claim 14, wherein the third capillary flow control module 430 comprises a first channel 431 connected to the B reaction part 250, a second channel 432 connected to the third bypass channel 218, a

venturi channel 433 disposed between the first channel 431 and the second channel 432, at least one third flow delay part 434 formed in the venturi channel 433 to delay the flow, and an air exhaust channel 435 connected to the third flow delay part 434 to discharge air bubbles between the first microfluid and the second microfluid.

19. The lab-on-a-chip according to claim 14, wherein the fourth capillary flow control module 530 comprises a first channel 531 connected to the second charging part 260, a second channel 532 connected to the detection part 290, a venturi channel 533 formed between the first channel 531 and the second channel 532, at least one fourth flow delay part 534 formed in the venturi channel 533 to delay the flow, and an air exhaust channel 535 connected to the fourth flow delay part 534 to discharge air bubbles between the first microfluid and the second microfluid.

20. The lab-on-a-chip according to claim 19, wherein the fourth capillary flow control module 530 may further comprise a flow stopping part 538 to stop the flow of the fluid between the second channel 532 and the fourth flow delay part 534.

21. The lab-on-a-chip according to claim 14, wherein a substrate is previously added to the A reaction part 220, an enzyme-detection antibody complex is previously added to the B reaction part 250 and a capture antibody is previously fixed on the C reaction part 270.

22. The lab-on-a-chip according to claim 14, wherein silver nitrate and hydroquinone as a reducing agent are previously added to the A reaction part 220, gold-detection antibody complex is previously added to the B reaction part 250 and capture antibody is previously fixed onto the C reaction part 270.

23. The lab-on-a-chip according to claims 5, 9 or 14, wherein a signal detection part of the capillary flow control module is designed to be applicable to the conventional well plate detecting apparatus and thus can detect signals using the convention well plate detecting apparatus.

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FIG. 1

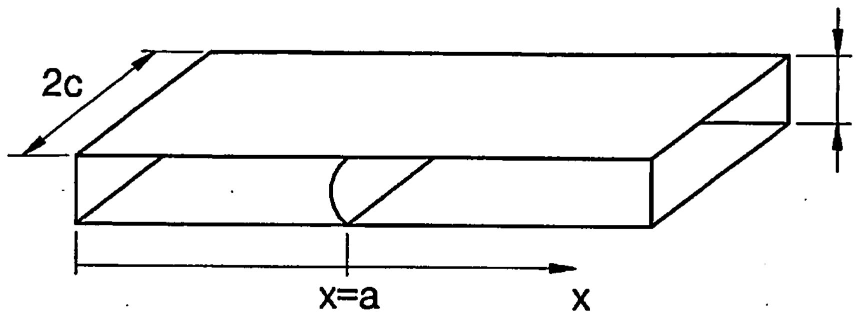

FIG. 2

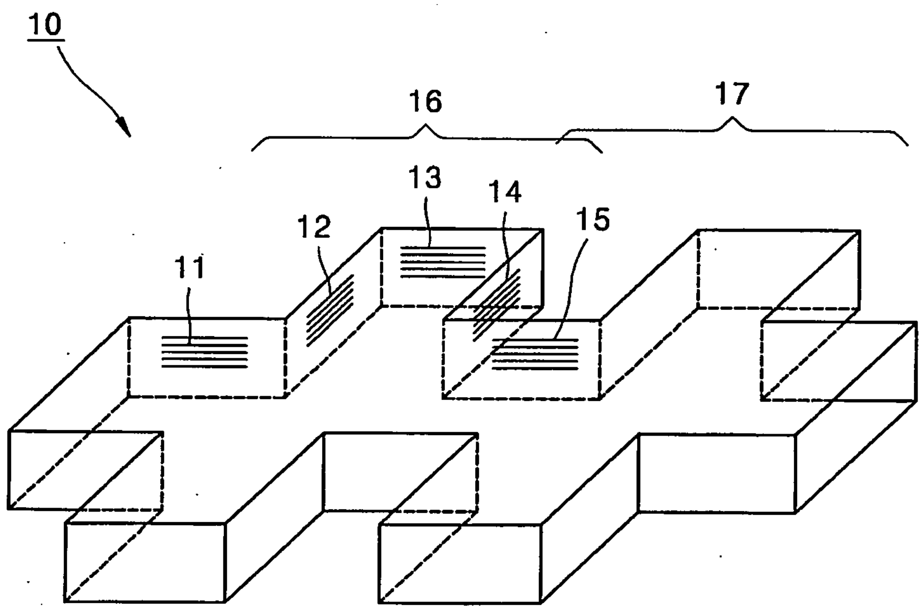

FIG. 3

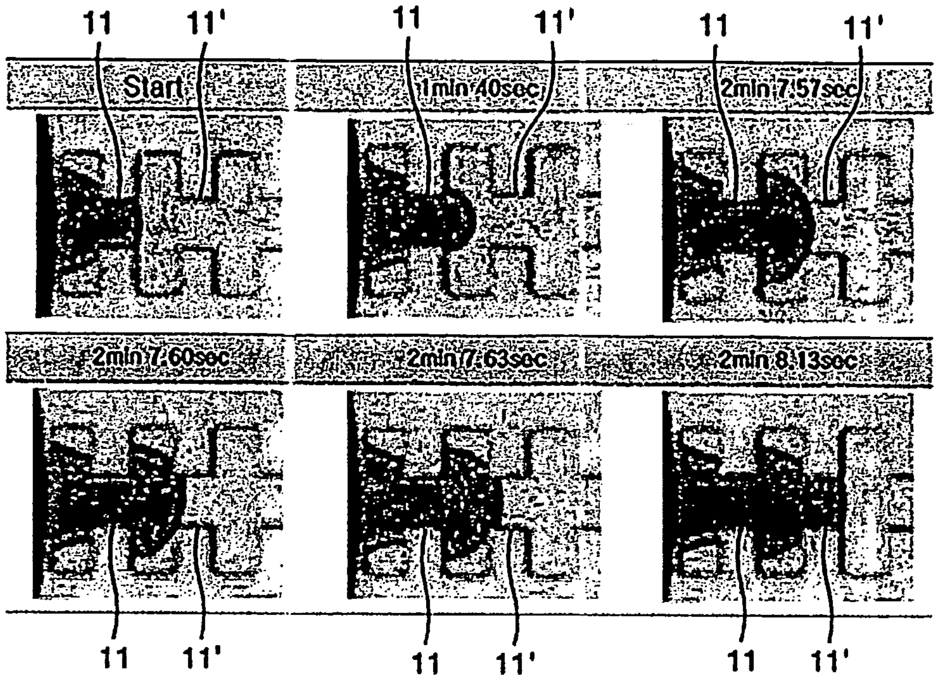
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FIG. 4

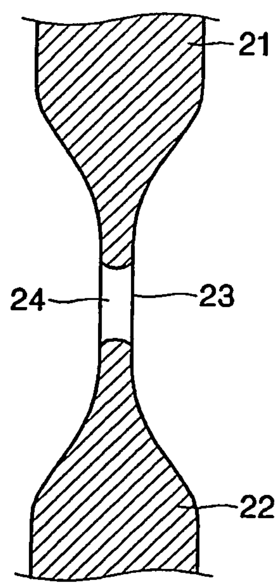
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FIG. 5

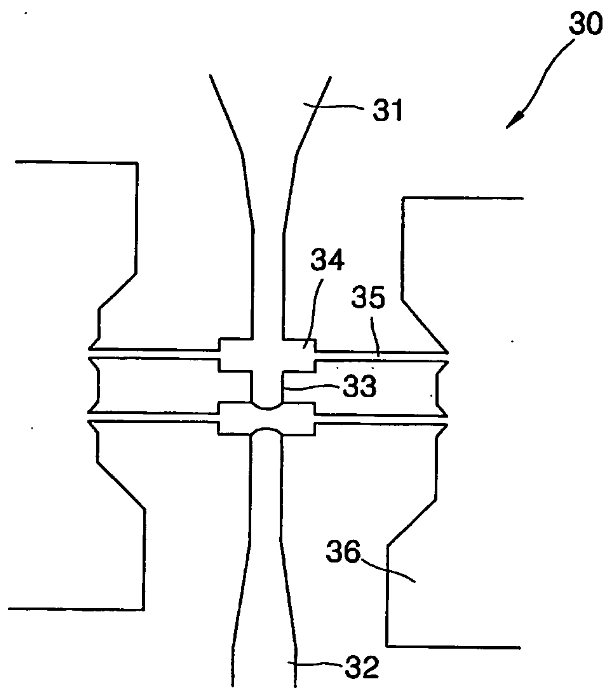

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FIG. 6

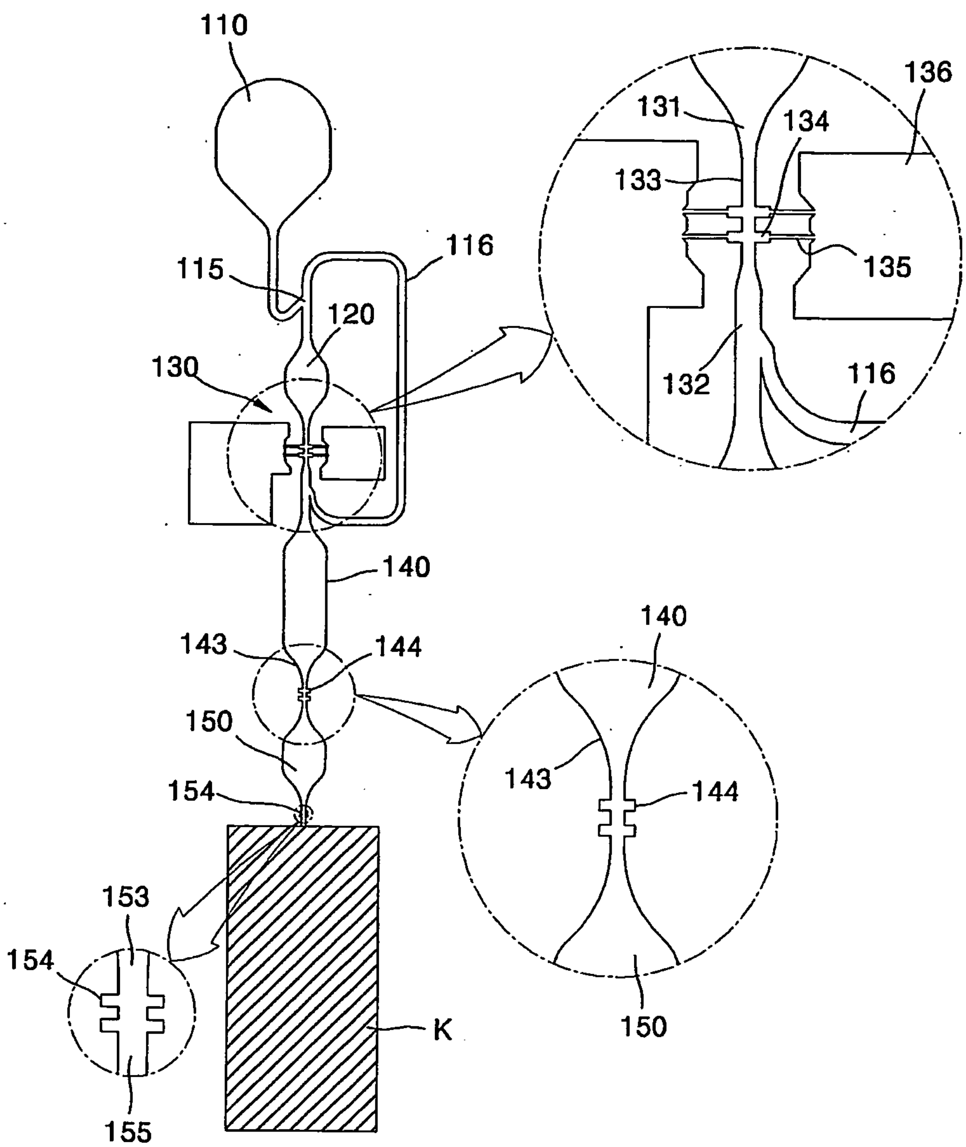
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FIG. 7

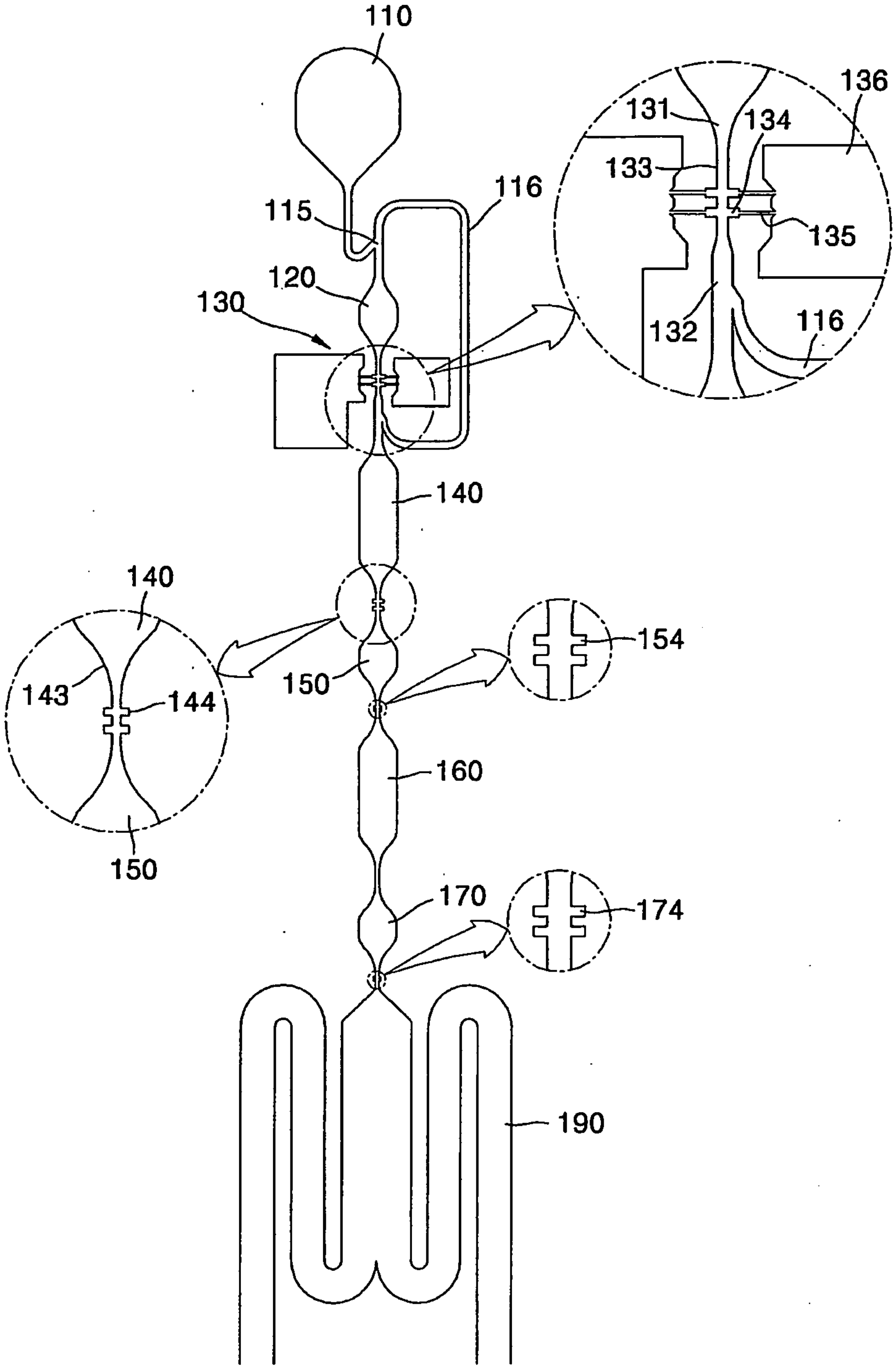
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FIG. 8

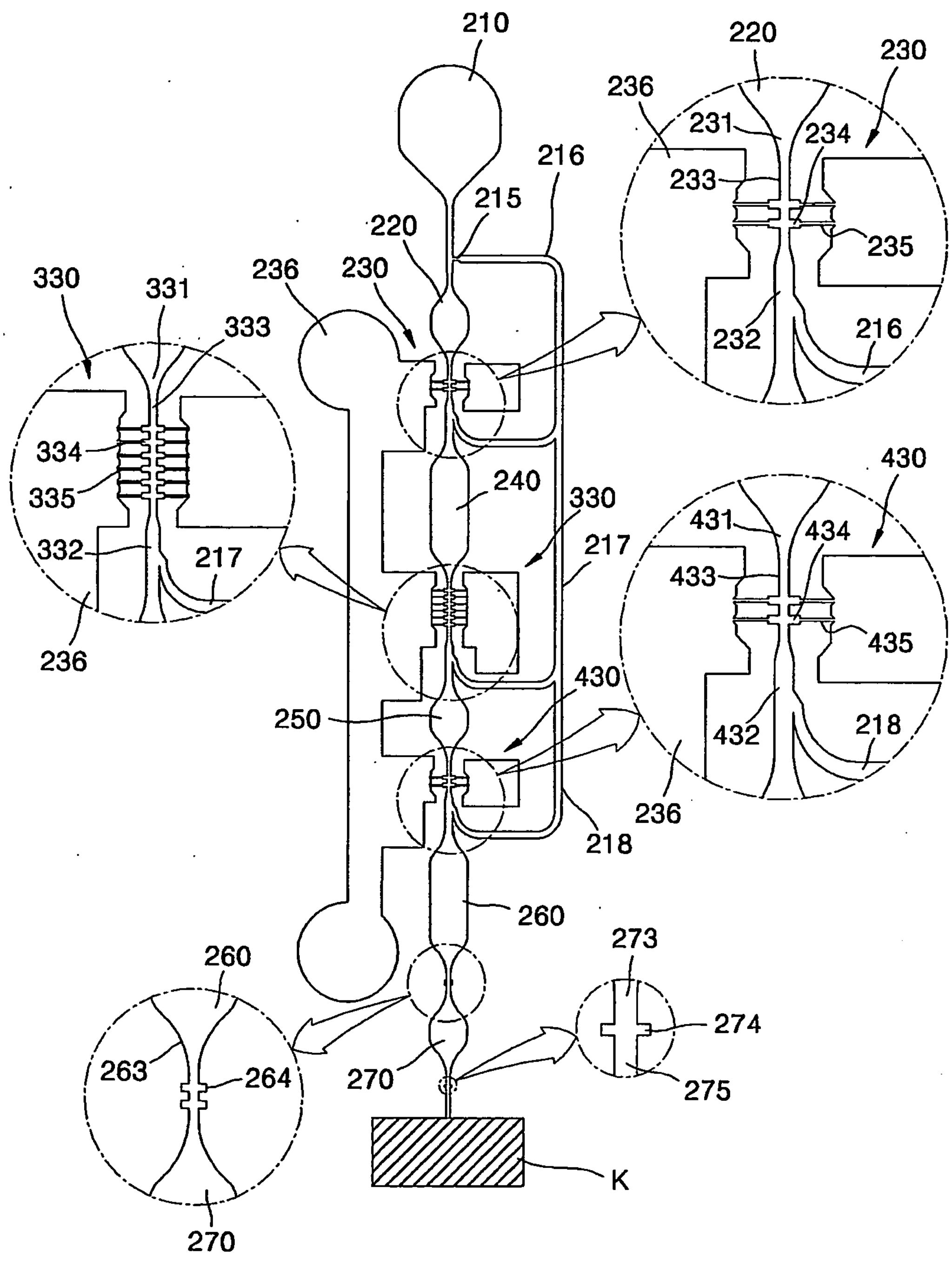

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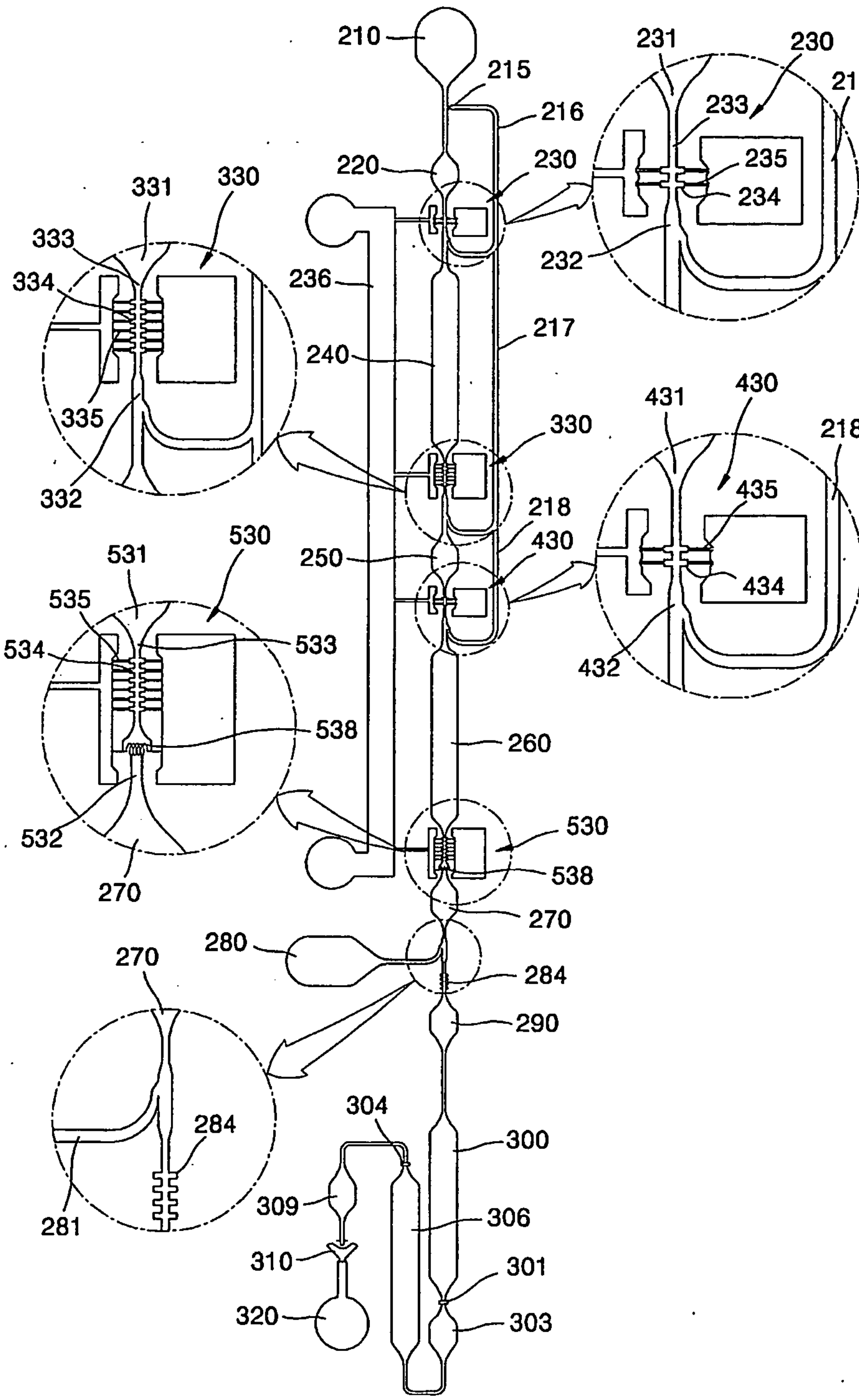
FIG. 9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PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference PP-B0163	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. **PCT/KR2005/002752**	International filing date *(day/month/year)* **19 AUGUST 2005 (19.08.2005)**	(Earliest) Priority Date *(day/month/year)* 21 AUGUST 2004 (21.08.2004)

Applicant

LG CHEM, LTD. et al

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
      ☐ The international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).
   b. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☐ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title**,
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract**,
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No. 6
      ☒ as suggested by the applicant.
      ☐ because the applicant failed to suggest a figure.
      ☐ because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2005/002752

A. CLASSIFICATION OF SUBJECT MATTER

IPC7 G01N 35/08, F04B 45/033

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC7 G01N 35/08, F04B 45/033

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Delphion, CA, PubMed "(capillary AND venturi AND flow AND delay*)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2003/0136736 (H. G. Craighead) 24 Jul. 2003	1-23
A	Lab. Chip., Vol.3, No.2, Apr. 2003, pages 106-113, J. S. Ko et al. : "A Polymer-Based Microfluidic Device forImmuno sensing Biochips"	1-23
A	US 2004/0028566 (J. S. Ko) 12 Feb. 2004	1-23
A	WO 2004/010086 (Mykrolis Corp.) 29 Jan. 2004	1-23

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 DECEMBER 2005 (01.12.2005)	**07 DECEMBER 2005 (07.12.2005)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea	CHANG, Je Hwan
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-8158

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR2005/002752

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US2003/0136736A1	24.07.2003	none	
US2004/0028566A2	12.02.2004	none	
WO2004/010086A2	29.01.2004	AU2003254011AA	09.02.2004
		EP1540562A2	15.06.2005
		KR1020050030204	29.03.2005